Fermilab

Final Report – March 23, 2013

Director's Cost and Schedule Assessment of the LHC CMS Detector Upgrade Project

May 15-16, 2013

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Executive Summary

It has been determined by the reviewers of the Director's Cost and Schedule Assessment of the LHC CMS Detector Upgrade project that the Project Team will be challenged to complete all requisite deliverables for a Director's Critical Decision 1 (CD-1) Readiness Review in June 2013. As requested by the Project Management Team, the review team provided a prioritized list of work that is to be accomplished to prepare for the Director's review. Furthermore, the review team estimates that several additional weeks are necessary to complete the requirements needed and prepare for a CD-1 review.

Significant estimating and scheduling work has been accomplished over the past several weeks; however, at the time of the Assessment, the project scope of work remained in flux, limiting the ability to present a credible estimate and schedule. The review team was encouraged at the Project Team's efforts to follow FNAL EVMS standards as related to estimating and scheduling. We note that substantial work remains to organize the estimates and complete the initial schedule logic prior to analyzing and optimizing the plan and integrating the plan into CERN's Master Project Plan. The review team recommends that an additional, experienced Project Controls Specialist be temporarily assigned to the CMS Detector Upgrade Team through the CD-1 review process.

It was apparent to the Review Team that the Project Team was very experienced and knowledgeable regarding the various detector components and their corresponding estimates. The back-up documentation could benefit from further organization of the presentation and quality control, with the understanding that reviewers must be able to trace the cost of the work from the Cobra Output (the estimate), through the Basis of Estimate and its supporting documentation. The review team believes that some of the processes could be streamlined using estimating and scheduling methods used on FNAL projects which recently completed successful CD-1 DOE reviews.

In conclusion, the reviewers were impressed by the technical knowledge of the Project Team, which is evidenced by the high level of detail contained within the Basis of Estimates and Schedule. Additional work is required to organize and present the data and ensure that it represents the clearly determined project scope.

1.0 Introduction

A Director's Cost and Schedule Assessment of the LHC CMS Detector Upgrade Project was held on May 15-16, 2013 at the Fermi National Accelerator Laboratory. This assessment was to look at the current state of the project schedule and cost development as they prepare for a Director's Critical Decision 1 (CD-1) Readiness Review. The charge included a list of topics and specific questions to be addressed as part of the review. The assessment of the Committee is documented in the body of this report.

This report is broken down into three basic sections after the Executive Summary. The first section is the assessments of the conceptual design of the project's deliverables. The assessment is generally organized by Findings, Comments and Recommendations. Findings are statements of fact that summarize noteworthy information presented during the review. The Comments are judgment statements about the facts presented during the review and are based on reviewers' experience and expertise. The comments are to be evaluated by the project team and actions taken as deemed appropriate. Recommendations are statements of actions that should be addressed by the project team. The second section gives the committee's answerers to the charge questions.

The last section of the report is the Appendices that contain the reference materials for this review. The Charge for this assessment is shown in Appendix A. The assessment was conducted per the agenda shown in Appendix B. The Assessment Committee is shown in Appendix C and Appendix D is a table that contains all the recommendations included in the body of this report.

The LHC CMS Detector Upgrade Project is to develop a response to the assessment team's recommendations and present it to the Laboratory Management and regularly report on the progress during the Project's Project Management Group Meetings (PMGs) and at the Performance Oversight Group (POG). The recommendations will be tracked in the iTrack system where progress to closure will be tracked.

2.0 Costs

Findings

- The CMS Upgrade project has a cooperative agreement between NSF and DOE to fund the entire U.S. scope of the project.

- The CMS team presented a preliminary funding profile provided by DOE with a TPC of $34M. The team stated the cost range provided by NSF is $10M - $13M. The total funding range for this project is $44M - $47M.

- The CMS team demonstrated how they use their BOEs as a cost estimating tool while they transition to P6 and Cobra. P6 and Cobra are the schedule and cost tools that will be used to manage the project.

- The CMS team presented how they plan to develop the cost range of the project as required by CD-1. The point estimate presented as the starting point for cost range development is known to have an error, due to some of the necessary resource rates being unavailable in Cobra.

- The team provided assumptions as to how costed and uncosted scientists would be handled on the project.

Comments

- The extra cost-estimation information in the current BOE format can lead to confusion during drill downs. The team should consider showing less detail for their BOE so that the reviewer only sees base costs and labor hours which can be compared to data in P6 and Cobra.

- The assumptions for how both scientific and technical resources, at Fermilab and elsewhere, will be handled on the project need to be defined unambiguously for the project and presented more clearly to reviewers. The rules should be consistent for all aspects of the project and documented in the assumptions document.

- Multiple problems with the BOE drilldown occurred, particularly with regard to backup documentation.   There are instances where the backup data does not coincide with the estimate provided. Some of the backup data includes costs for items that are not part of the estimate.

- The presentation given for the cost methodology did not include any details about how the method was applied, only the results from doing various steps. A reviewer would have a very hard time determining what the steps are without some form of diagram or reference as to how to repeat the methodology used.

- The CMS team presented their estimate uncertainty guidance, which was closely aligned with the developing lab standard. However, it was difficult to determine

the maturity of design for each BOE element, and thus difficult to determine whether the appropriate amount of contingency had been applied.

- The BOE and cost book forms used different terminology to reflect the same data, i.e. base vs. direct.

- The project's TPC is hard to determine at the moment because the project did not clearly define what scope was in the cost estimate and what scope was out with respect to NSF. The project did state that all DOE scope is covered in the cost estimate but they are still deciding what to include/exclude for the NSF scope. The team should make this clear before proceeding with any other aspect of the project.

Recommendations

1. The CMS team needs to clearly define what part of the NSF scope is included under the CMS Upgrade project that will be managed using FNAL's EVMS.

2. The CMS team needs to find out what the funding profile will be for NSF so that they can plan the work within that guidance.

3. The CMS team needs to complete their technical schedule as soon as possible so that they can properly plan how to accomplish all the work within the funding guidance provided by NSF and DOE.

4. The CMS team should perform a BOE audit and clean up the backup documentation. This includes verifying the links, clarifying what line items in quotes are included in the cost, the quantity of the item and unit price, and removing any documentation that is not directly related to the estimate provided.

5. The CMS team should include quantitative values with their estimate uncertainty rules for the level of design maturity. The team should update their presentations so that design maturity is clearly stated for each Level 3 area or below, as appropriate. They should perform an analysis on the project's overall level of design maturity as an aid in creating the cost and schedule range.

6. The CMS team should use consistent terminology (e.g. base vs. direct) in all forms of data presentation so that reviewers have a clear path to making valid comparisons.

7. The CMS team should document the cost estimating methodology used in the form of a chart or steps so that anyone could duplicate the steps easily to verify the cost range.

8. The CMS team should provide any and all rules used for scientific and non-scientific labor at FNAL and not at FNAL in their assumptions document.

9. The CMS team should configure the Cost Processor, Cobra, to include the proper rates for university personnel.

3.0 Schedule

Findings

- The project BOE documents have been entered into P6, including schedule activities, resource assignments and quantities, durations and internal logical relationships.

- The minimum of coding necessary to bring these costs into Cobra has been performed.

Comments

- Because direct import of BOE data into P6 was not performed, a great deal of QC inspection and correction of incomplete or incorrect data is necessary before this initial data entry can be considered complete or correct.

- A primary concern is that the three different L2 component projects of the USCMS Upgrade project have not applied a common set of policies regarding how differently-funded work will be included in the schedule. The scope of the project is not therefore consistently included (or excluded) from the project resource-loaded schedule.

- The schedule currently contains only BOE-internal relationships (at the level of the terminal WBS category). Management tasks which are currently driving the apparent critical path must be detached from the technical critical path.

Recommendations

10. It is recommended that one additional full-time experienced Project Controls Specialist be dedicated to the schedule preparation effort.

11. The project team should develop of a common set of consistently-applied policies regarding how work which is DOE-funded, NSF-funded via a laboratory, NSF-funded via another collaboration partner, CERN-funded, an in-kind contribution, or off-project entirely, will each be represented in the schedule and on BOE documents.

12. Necessary review activities, including the durations required for preparing for, conducting, and waiting for approvals following reviews, must be included in the schedule.

13. External events, such as the LHC shut-down schedule or the releases of funding by various agencies, should be represented on the schedule in a consistent way.

14. Obligation tasks for all procurements with duration longer than a reporting period, and planning packages with sufficient duration for critical-path procurements, must be included.

15. CD-3a early procurements should be identified.

16. Once all project scope is known and correctly represented on the schedule, complete internal and external logical relationships must be provided in order that the critical path may be known.

17. When the critical path is identified and iterated, additional logical relationships to funding releases should be added to level the project obligations to the DOE and NSF funding profiles.

18. Additional work which should be completed prior to the DOE CD-1 review includes resource leveling, complete coding of tasks for EDIA categories, estimate types and other expected data, correction of temporary resources to permanent, more accurately-priced resources and fully detailing critical path and other procurement activities occurring prior to CD-3.

4.0 Risk

Findings

- The CMS Upgrade Team presented a Draft Risk Management Plan that supplements the Fermi Draft Risk Procedure.

- The Team presented a Preliminary Risk Register identifying risk events associated with the upgrade.

- The Team is aware of their shortcomings in their Risk Program and is working to complete their documentation.

Comments

- A good deal of effort was put into the identification of risk events. Continuing with this effort with qualitative analysis will help to identify the top Project risk events.

- A more accurate cost estimate is obtained when the risk information assembled is as complete as possible.

Recommendations

19. Complete Risk Matrix; the presented Risk Register lacked the appropriate detail describing the matrix elements of the risk. Complete qualitative analysis and rank risks appropriately.

20. After the risks have been updated and ranked, the Project should hold a risk workshop to analyze each risk in a full project environment for discussion.

21. Remove the Currency Risk from the estimate uncertainty factor in the BOEs and include it as a risk event. This is called out specifically as a risk and needs to be accounted for in the Risk Register with appropriate modeling, rather than inflating the estimate uncertainty.

5.0 Charge Questions

1. **At what state is the Project's resource loaded schedule and what is needed to reach a quality CD-1 level?**

   The Resource Loaded Schedule continues to be constructed, and is not yet in a state to produce a creditable estimate or critical path. The work remaining is significant and includes; configuring the scheduling and cost tools with additional university resources, ensuring that the scope of the project coincides with the scheduled effort, completing the schedule logic to develop a technically driven schedule, completing schedule iterations until the funding profile is optimized and ensuring that all off-project constraints are represented in the schedule.

2. **Is the cost and schedule range, or the methodology of how they will develop that range, realistic and justified by the supporting documentation (including BOEs)? Has all the work been appropriately identified, estimated and scheduled?**

   The Project Team presented their proposed cost and schedule range methodology, which remained a work in progress. Additional evaluation regarding the maturity of the design and risk assessment is needed to apply the AACEi principles, as outlined in DOEs Cost Estimating Guide (DOE G 413.3-21). As noted in item 5.1 above, the scope, cost and schedule continues to evolve.

3. **Has the Project implemented a Risk Management Process by identifying risks, performing a risk assessment and started developing mitigation plans at an appropriate level for the CD-1 stage, if not , what is needed to get there?**

   The Project Team has a robust list of risk events; however additional efforts are required associated with risk assessment and mitigation. The Project Team needs to complete the qualitative assessment of the cost and schedule risk in order to complete the corresponding ranges.

4. **Is the scope of work clearly defined between what is funded by DOE or NSF, and is this reflected in the cost, schedule and risk assessment presented to the committee?**

   The Project Team advised that the differentiation between DOE, NSF and off-project work continues to be sorted out by the various stakeholders. The Basis of Estimates and Schedule will be revised once finalized.

5. **What is the state of readiness of the LHC CMS Detector Upgrade Project cost and schedule development for a Director's CD-1 Readiness Review?**

   The Project is not yet ready for a Director's CD-1 Readiness Review. The review team provided a prioritized list of items to complete prior to the review along with a draft plan for context. The review team believes the Project Team can be ready for a Director's CD-1 Readiness Review in 6-8 weeks, if the recommendation to add Project Controls effort is followed and a high level of Project Team effort is maintained.

6.0 Appendices

a) Charge
b) Agenda
c) Assessment Committee
d) Table of Recommendations

Appendix A

Charge

The Committee is to conduct a Director's Cost and Schedule Assessment of the LHC Compact Muon Solenoid (CMS) Detector Upgrade Project. This assessment it to look at the current state of the project schedule and cost development as they prepare for a Director's Critical Decision 1 (CD-1) Readiness Review The main focus of the committee is to give feedback to the project on what is necessary to get from the current state to the required CD-1 state. The LHC CMS Detector Upgrade Project received CD-0 on September 18, 2012. The Project anticipates receiving DOE Critical Decision 1 (CD-1) "Approve Alternative Selection & Cost Range" late summer of 2013.

The LHC CMS Detector Upgrade Project is the design and construction of upgrades to the Hadron Calorimeter, the Silicon Pixel detector, and the Level 1 Trigger subsystems of the CMS detector at CERN. The LHC, running at 8 TeV center of mass energy, has nearly reached its design luminosity. It is expected that with planned upgrades, it will exceed the original design by a factor of at least two. CMS was not designed to run efficiently at the luminosity now projected for the next several years. With these upgrades, the detailed study of the properties of the new boson and the search for new physics that should be associated with it can take full advantage of the excellent performance of the LHC and resolve many of the open questions in electroweak physics.

The project will present a Cost Range or a methodology for developing the Cost Range. The committee is to assess and determine if it is appropriate based on the following factors: the scope of work; the maturity of the design; the Basis of Estimate (BOE); and the risks associated with the scope of work. The team will also look at the WBS – Work Breakdown Structure, WBS Dictionary, BOE – Basis of Estimate documentation, risk and contingency analyses, RLS – Resource Loaded Schedule, and time phased funding and cost profiles. The committee is asked to review each of these items, for quality, completeness, and accuracy and to address the following questions to assess the Project's progress:

1. At what state is the Project's resource loaded schedule and what is needed to reach a quality CD-1 level?

2. Is the cost and schedule range, or the methodology of how they will develop that range, realistic and justified by the supporting documentation (including BOEs)? Has all the work been appropriately identified, estimated and scheduled?

3. Has the Project implemented a Risk Management Process by identifying risks, performing a risk assessment and started developing mitigation plans at an appropriate level for the CD-1 stage, if not , what is needed to get there?

4. Is the scope of work clearly defined between what is funded by DOE or NSF, and is this reflected in the cost, schedule and risk assessment presented to the committee?

5. What is the state of readiness of the LHC CMS Detector Upgrade Project cost and schedule development for a Director's CD-1 Readiness Review?

Finally, the committee should document their comments, recommendations, and answers to the above questions in a written report that will be provided Fermilab's management and the LHC CMS Detector Upgrade Project.

Appendix B

Agenda

Wednesday, May 15th (Hornets' Nest – WH8X)

1:00-1:40 – Presentation on Approach to Estimate, Schedule and Contingency Development (Erik Gottschalk)

1:40-2:40 – Cost/Schedule Drilldown HCal - Jeremy Mans

2:40-3:00 – Break

3:00-4:00 – Cost/Schedule Drilldown FPIX - Will Johns

4:00-5:00 – Cost/Schedule Drilldown Trigger and PM - Wesley Smith

5:00-6:00 – Committee meeting

Thursday, May 16th (Snake Pit WH2NE)

8:00-9:00 – Risk Approach and Risk Register Review - Lucas Taylor

9:00-9:15 – Break

9:15-10:00 – CD-1 Range – Joel Butler

10:00-10:30- Roundtable Discussions with Project

10:30-12:00 – Committee Wrap-up with deliverable of Questions/ Comments

Follow-up Actions:

May 17th (End of Day) – CMS team reply to Questions/ Comments

May 18th- May 23rd – Committee Write Report, Review and Final Production/ Posting of Report

Appendix C

Assessment Committee

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Appendix D

Table of Recommendations

#	Recommendations	Assigned to	Status/Action	Date
2.0	**Costs**			
1	The CMS team needs to clearly define what part of the NSF scope is included under the CMS Upgrade project that will be managed using FNAL's EVMS.			
2	The CMS team needs to find out what the funding profile will be for NSF so that they can plan the work within that guidance.			
3	The CMS team needs to complete their technical schedule as soon as possible so that they can properly plan how to accomplish all the work within the funding guidance provided by NSF and DOE.			
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8	The CMS team should provide any and all rules used for scientific and non-scientific labor at FNAL and not at FNAL in their assumptions document.			
9	The CMS team should configure the Cost Processor, Cobra, to include the proper rates for university personnel.			
4.0	**Schedule**			
10	It is recommended that one additional full-time experienced Project Controls Specialist be dedicated to the schedule preparation effort.			
11	The project team should develop of a common set of consistently-applied policies regarding how work which is DOE-funded, NSF-funded via a laboratory, NSF-funded via another collaboration partner, CERN-funded, an in-kind contribution, or off-project entirely, will each be represented in the schedule and on BOE documents.			
12	Necessary review activities, including the durations required for preparing for, conducting, and waiting for approvals following reviews, must be included in the schedule.			
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14	Obligation tasks for all procurements with duration longer than a reporting period, and planning packages with sufficient duration for critical-path procurements, must be included.			
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17	When the critical path is identified and iterated, additional logical relationships to funding releases should be added to level the project obligations to the DOE and NSF funding profiles.			
18	Additional work which should be completed prior to the DOE CD-1 review includes resource leveling, complete coding of tasks for EDIA categories, estimate types and other expected data, correction of temporary resources to permanent, more accurately-priced resources and fully detailing critical path and other procurement activities occurring prior to CD-3.			
4.0	**Risk**			
19	Complete Risk Matrix; the presented Risk Register lacked the appropriate detail describing the matrix elements of the risk. Complete qualitative analysis and rank risks appropriately.			
20	After the risks have been updated and ranked, the Project should hold a risk workshop to analyze each risk in a full project environment for discussion.			

21	Remove the Currency Risk from the estimate uncertainty factor in the BOEs and include it as a risk event. This is called out specifically as a risk and needs to be accounted for in the Risk Register with appropriate modeling, rather than inflating the estimate uncertainty.			